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盐度和基质对老鼠簕生长及
总黄酮含量的影响

Effects of Salinity and Sediments to Growth and Total
Flavonoids Content of *Acanthus ilicifolius*

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摘 要

通过设置不同盐度、基质的室外培养实验,研究了老鼠簕(*Acanthus ilicifolius* L.)在不同盐度和基质生境条件下的生长、生理特性及体内总黄酮含量的变化。设计6个盐度水平:0、5、10、15、25和35;5个基质水平:100%海泥+0%砂、70%海泥+30%砂、50%海泥+50%砂、30%海泥+70%砂(V/V)、红壤土,均以盐度5的人工海水进行培养,分别用0%、30%、50%、70%、RS表示。培养365 d。分析探讨了盐度、基质对老鼠簕幼苗的生长、生物量分配、光合作用、丙二醛含量(MDA)、游离脯氨酸含量、过氧化氢酶(CAT)、过氧化物酶(POD)、超氧化物歧化酶(SOD)、苯丙氨酸解氨酶活性(PAL)、体内总黄酮含量的影响,并且测定了野外老鼠簕植物体内总黄酮含量的月变化情况。结果表明:

老鼠簕幼苗在盐度5的条件及不含砂的海泥基质条件下茎高生长最佳,较高盐度和较低营养水平的基质培养下均受到抑制。盐度由0增加到35后,老鼠簕幼苗长叶数和落叶数均分别减少62.1%和39.6%,叶片数减少65.5%。单株叶面积在盐度5的条件下最大,之后随盐度升高而降低,盐度35的条件下减少了22.99 cm²;基质中营养水平的降低,使长叶数下降,落叶数增加,含砂70%的基质中植株叶片数量和叶面积分别为不含砂的基质条件下植株的43.9%和52.2%。盐度和基质对老鼠簕植株生物量及其分配有显著影响($p < 0.05$)。收获的各器官生物量均在盐度5条件下最大,盐度超过5后随盐度增加而降低;根生物量比(RMR)、根冠比(R/C)随盐度增加而增加,盐度0的条件下RMR和R/C分别为盐度35下的56.3%和87.9%;叶生物量比(LMR)在盐度5的条件下最高,随后降低,盐度35条件下的LMR仅为盐度5下的63.0%。表明在盐渍胁迫下,老鼠簕地上部分受到的抑制较地下部表现明显。老鼠簕各器官生物量在不含砂的海泥基质中最大。RMR、R/C随基质营养水平的下降而增加,两者的最低值分别为最高值的82.0%和36.7%;LMR随营养水平降低而下降,RS基质条件下的LMR较不含砂基质降低了58.2%。说明在较低营养条件下,老鼠簕趋向于发展更多的根系。

在0~35盐度范围内,老鼠簕幼苗叶绿素含量先升高后降低,在盐度5的处理下达最高值,在盐度35处理下达最低值;类胡萝卜素含量的变化较小。盐度对老鼠簕光合特性的影响为:净光合速率(Pn)和气孔导度(Gs)在0~10盐度

范围内差异不大，盐度超过 10 后随盐度升高而降低；胞间 CO_2 浓度（ Ci ）则先升高后降低，以盐度 5 条件下最高，盐度 35 条件下最低；盐度对蒸腾速率（ Tr ）的影响未达到显著水平。这说明，老鼠簕幼苗在较高盐度下光合速率降低的主要原因为气孔限制。不同基质处理的结果表明，随着营养水平的下降，老鼠簕幼苗叶绿素含量持续降低，类胡萝卜素含量变化不大。老鼠簕幼苗 Pn 随营养元素含量降低而降低， Gs 先升高后降低，在含砂 30%的基质处理下达最高值， Ci 值和 Tr 值则持续升高。这说明，在较低营养水平下老鼠簕幼苗 Pn 下降的主要原因可能是非气孔限制。

不同盐度处理下的老鼠簕植物，根系活力随盐度升高而降低，叶片 MDA 和游离脯氨酸含量均先降低后持续升高。叶片抗氧化酶系统活性的变化为：CAT 活性持续升高，POD 和 SOD 活性在低盐范围内（盐度 0~10）升高，高盐范围内（盐度 15~35）降低。其中 MDA 含量与 POD、SOD 活性呈显著负相关（ $p < 0.05$ ），说明老鼠簕在较高盐度下受到的膜脂过氧化伤害增强。不同基质处理下，老鼠簕幼苗根系活力随营养元素含量下降而降低，MDA 含量增加，游离脯氨酸含量没有明显变化。叶片酶活性的变化为：CAT 和 POD 活性持续降低，SOD 活性在含砂 30%的基质处理下略有升高，后持续下降。这说明在较低营养水平下，老鼠簕体内抗氧化酶活性降低。

通过正交实验确定了老鼠簕总黄酮索氏和超声提取方法的最佳条件。索氏提取法的最佳条件为 60%乙醇作提取液，于 85°C 下乙醇回流 2.5 h，总黄酮得率为 3.74%；超声提取法的最佳条件为 50%乙醇作提取液，液料比（V/W）为 40 : 1，超声处理 50 min，总黄酮得率为 3.82%。综合考虑提取结果和经济因素，以超声提取法较佳。

盐度对老鼠簕幼苗各器官中总黄酮含量的影响情况不同。叶片中总黄酮含量随盐度升高而升高，盐度 35 的条件下叶片总黄酮含量为盐度 0 下的 1.85 倍；根中总黄酮含量在盐度 0~15 范围内变化不大，而盐度超过 15 后则显著增加；茎中总黄酮含量总体波动幅度较小。随着基质营养水平的下降，老鼠簕叶片与根中总黄酮含量均先升高后降低，以含砂 30%的基质处理下最高（叶：11.22 mg/g，根：3.91 mg/g），RS 基质下最低（叶：4.73 mg/g，根：1.86 mg/g），茎中总黄酮含量则随营养元素含量降低而降低。总体来说，老鼠簕幼苗各器官总黄酮含量为叶中

> 茎中 > 根中。不同盐度下老鼠簕叶片 PAL 活性的随盐度升高而增加, 盐度 35 的条件下 PAL 活性比盐度 0 下高 169.6%。不同基质下的叶片 PAL 活性则先升高后降低, 含砂 30% 的基质下最高 (133.17 u/gFW·min), RS 基质下最低 (93.18 u/gFW·min), 与总黄酮含量的变化趋势相似, 说明不同处理条件可能是通过影响老鼠簕体内的相关酶活性从而影响总黄酮含量。

对野外生长老鼠簕各器官总黄酮含量的监测结果表明, 叶片中总黄酮含量在生殖期较高, 生长期较小, 夏季较高, 秋季较小; 茎中总黄酮含量变化趋势与之相似, 但波动较小; 花中总黄酮含量蕾期高于盛花期, 种子中总黄酮含量高于种皮。总体看来, 各器官总黄酮含量分布为叶中 > 种子中 > 花蕾中 > 花中 > 茎中 > 种皮中。

关键词: 老鼠簕; 盐度; 基质; 生长; 总黄酮

Abstract

Acanthus ilicifolius L. seedlings were cultivated out of doors and treated with different levels of salinity and sediments. 6 levels of salinity were 0, 5, 10, 15, 25, 35. 5 levels of sediments were 100% sea mud(0% sandy), 70% sea mud+30% sand(30% sandy), 50% sea mud+50% sand(50% sandy), 30% sea mud+70% sand(70% sandy), red soil(RS). All seedlings in different sediments were treated with same salinity 5. The cultivating period lasted 365 days. Systemic study on *Acanthus ilicifolius* were carried on growth, biomass allocation, chlorophyll and MDA and free proline content, photosynthetic properties and the activity of CAT, POD, SOD and PAL, total flavonoids. The change of total flavonoids through different months in wild *Acanthus ilicifolius* was also studied. The results showed:

Stems of plants under salinity 5 and 0% sediments were the highest, the stem height of higher salinity and sediments of lower nutrient content was restrained. As the salinity rose to 35, the number of leaf production and fallen leaves decreased by 62.1% and 39.6% respectively, number of leaves decreased by 65.5%. Leaf area per plant reached maximum under salinity 5, then decreased as the salinity went up. The leaf area per plant under salinity 35 decreased by 22.99 cm². Under low nutrient content sediments, both the numbers of leaf production and fallen leaves decreased. The number and area of leaves per plant under 70% sandy sediments were 43.9% and 52.2% of which under 0% sandy sediments respectively. Biomass and their distribution under different salinity and sediments changed significantly ($p < 0.05$). The maximum biomass of different parts appeared under salinity 5, then decreased as the increase of salinity; RMR and R/C value rose as the increase of salinity, which under salinity 0 were 56.3% and 87.9% of the value under salinity 35 respectively; LMR reached maximum under salinity 5, then decreased, the LMR under salinity 35 was only 63.0% of which under salinity 5. The results indicated that under high salinity stress, shoot of *Acanthus ilicifolius* was restrained more than root. Plants

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